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(54) **A level limit switch for electrically conducting filling materials**

(57) A level limit switch for an electrically conductive filling material (3) has a probe (4) which is arranged at the height (h) of the level to be ascertained. The container wall (2) forms an earth electrode (9) which is permanently in contact with the filling material (3). The probe (4) has a sensor electrode (7) which comes into contact with the filling material (3) when the filling material (3) reaches the height of the probe (4). An intermediate electrode 8 is arranged between the sensor electrode 7 and the earth electrode 9. A resistor 16, connects the intermediate electrode 8 to the sensor electrode 7. The alternating voltage is applied between the earth electrode 9 and the intermediate electrode 8 and the alternating voltage prevailing between the sensor electrode 7 and the earth electrode 9 is supplied to an evaluating circuit 11. The level limit switch is insensitive to extension formations of filling material on the probe and to variations in the conductivity of the filling material.

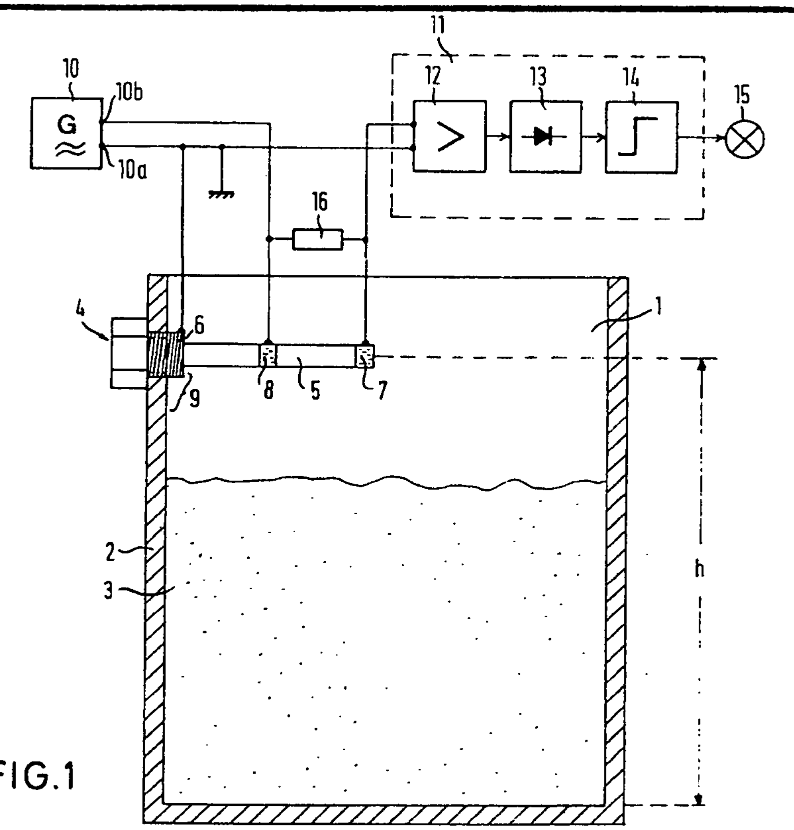

FIG.1

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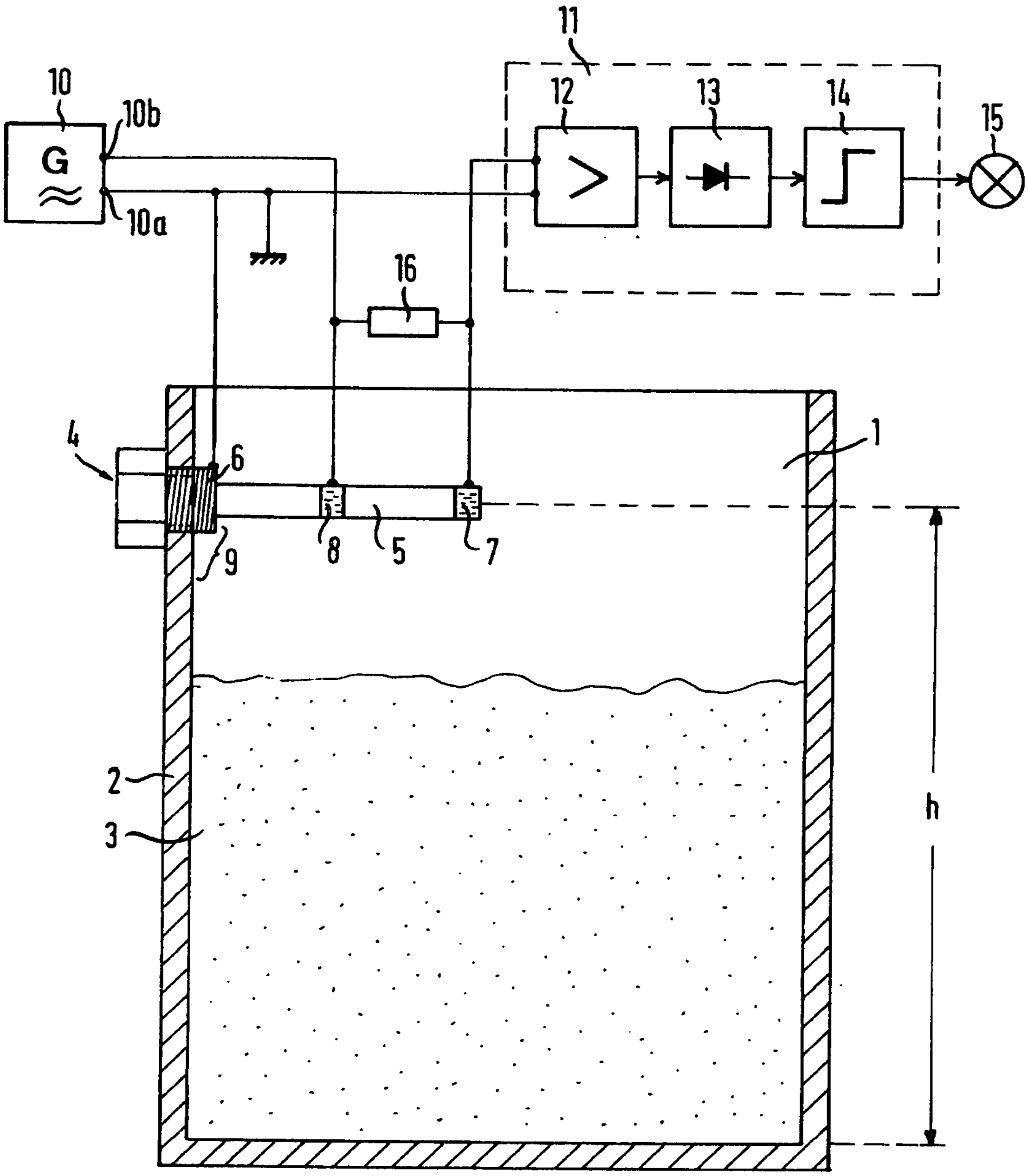

FIG.1

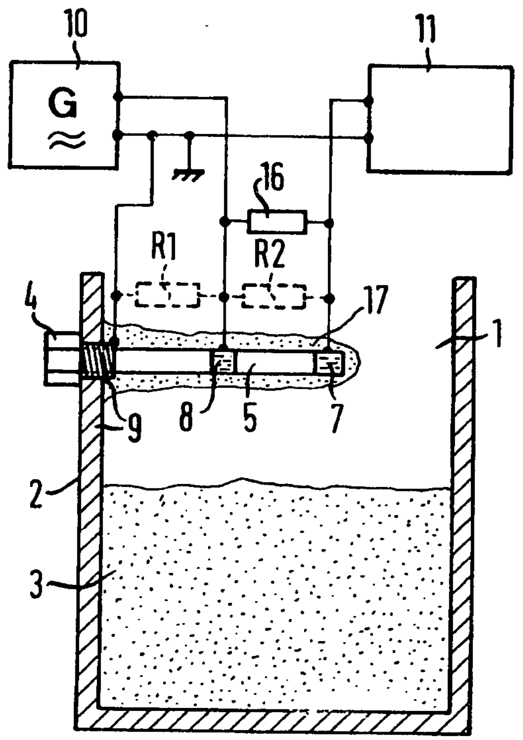

FIG.2

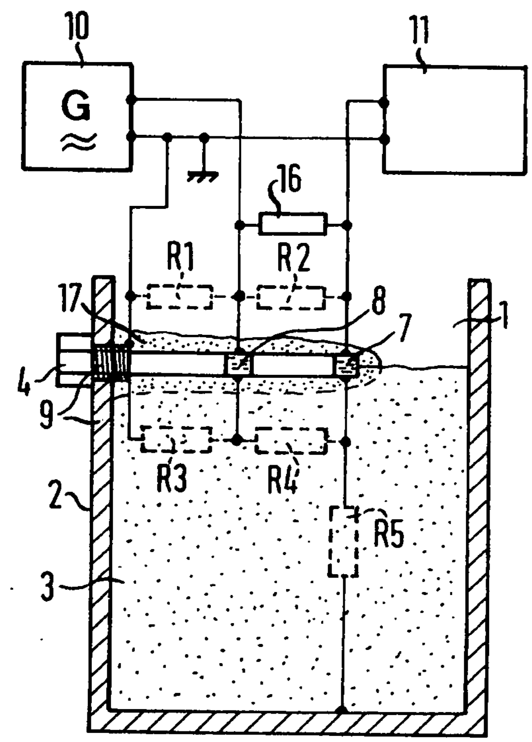

FIG.4

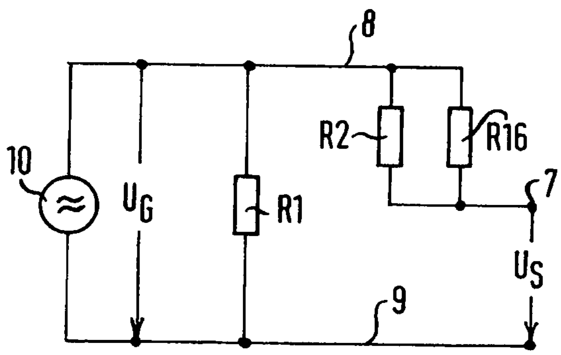

FIG.3

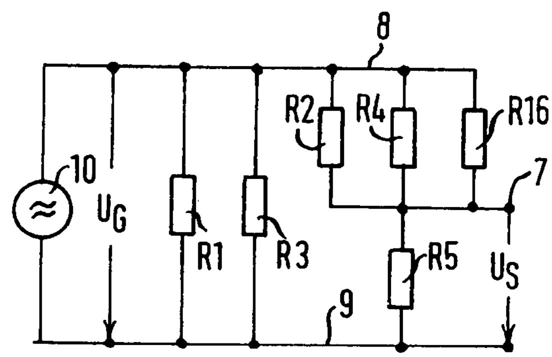

FIG.5

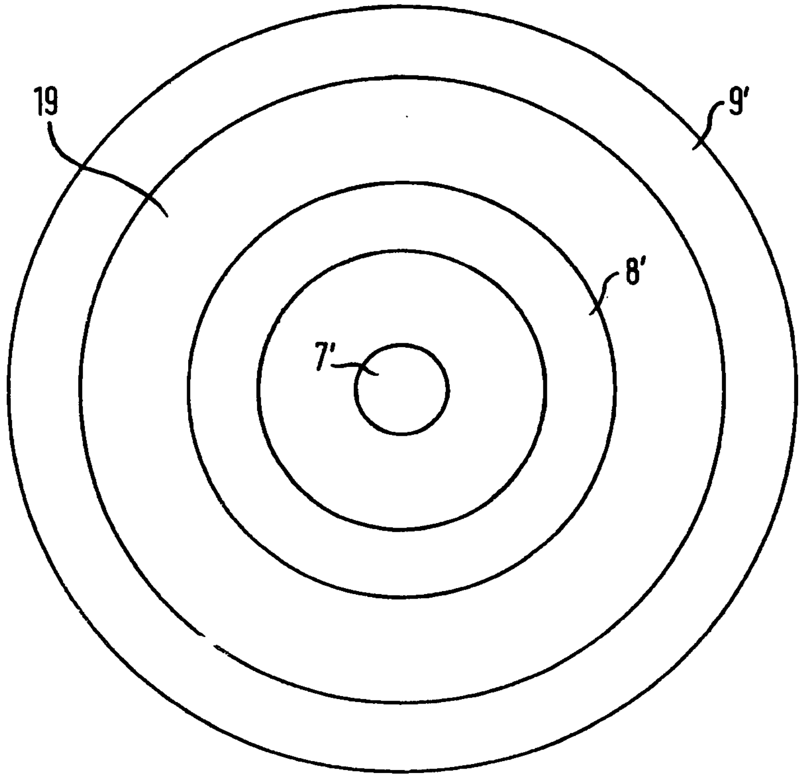

FIG.6

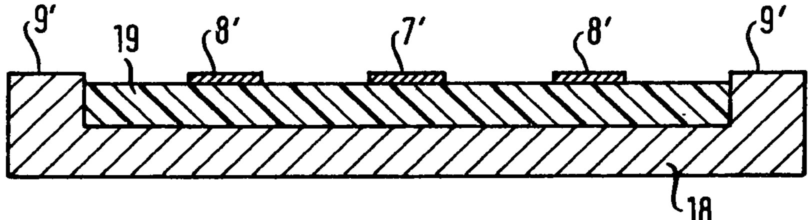

FIG.7

SPECIFICATION

A level limit switch for electrically conducting filling materials

The invention relates to a level limit switch for electrically conducting filling materials, comprising a probe arranged at the height of the level to be determined and which has a sensor electrode which comes into electrical contact with the filling material when the latter has reached the level to be ascertained and comprising an earth electrode which is in electrical contact with the filling material at least when the latter has reached the level to be ascertained, comprising an arrangement for applying an alternating voltage to the electrodes and comprising an evaluating circuit which is connected to the sensor electrode and to the earth electrode and responds to variations in the electrical signal.

With level limiting switches of this kind, the filling material forms an electrical conductance between the sensor electrode and the earth electrode as soon as it comes into contact with the sensor electrode so that a current flows due to the applied alternating voltage. The evaluating circuit either responds to the flow of current or to a voltage drop produced by the current flow and thus indicates the level to be ascertained.

When level limit switches of this kind are used for filling materials and which are inclined to form extensions, the danger exists of false indications. Fruit juices, jams, mustard and other viscous or sticky media belong, for example, to such filling materials. After repeated covering of the probe by such a filling material an extension is formed on the probe which as substantially the same conductivity as the filling material. The extension forms a conductive connection between the sensor electrode and the earth electrode even when the level has not reached the height of the probe. As a result of the current flowing through this conductive connection, the evaluating circuit indicates the reaching of the level to be ascertained even when the probe is not immersed in the filling material.

The specific conductivity of the filling materials for which such level limit switches are used, varies between wide limits and can be subject to considerable variations during the course of time even with the same filling material. Consequentially, the values of the alternating current flowing between the sensor electrode and the earth electrode are also different. The evaluating circuit indicates the reaching of the level to be ascertained when the said current exceeds a predetermined threshold value. Thus, the response threshold of the evaluating circuit must be set in accordance with the particular conductivity of the filling material and false indications can result when the conductivity of the filling material changes.

In accordance with this invention, there is provided a level limit switch for electrically conducting filling materials, comprising a probe arranged at the height of the level to be ascertained, and having a sensor electrode arranged to come into electrical contact with the filling material when the latter has reached the level to be ascertained and an intermediate electrode, the switch further comprising an earth electrode arranged to come into electrical contact with the filling material at least when the latter has reached the level to be ascertained, means for applying an alternating voltage between the earth and intermediate electrodes and an evaluating circuit connected to the sensor and earth electrodes to respond to variations in the electrical signal between the sensor electrode and the earth electrode.

When the probe in the level limit switch according to the invention is covered with the filling material the sensor electrode forms the tapping of a potentiometer the resistance branches of which are formed by the filling material which bridges on the one hand the intermediate space between the sensor electrode and the earth electrode and on the upper hand bridges the intermediate space between the sensor electrode and the intermediate electrode. An extension present on the probe between the sensor electrode and the earth electrode acts in the same manner as the filling material bridging that intermediate space. Thus, an alternating voltage is available to the sensor electrode which is lower than the alternating voltage applied to the intermediate electrode in accordance with the voltage divider ratio of the potentiometer. The filling material which bridges the intermediate space between the intermediate electrode and the earth electrode forms a conductance which is in parallel with the potentiometer and thus does not influence the voltage division. The same applies to an extension which has formed between the intermediate electrode and the earth electrode.

On the other hand, when the filling material has not reached the level determined by the installed height of the probe and does not therefore contact the probe and its electrodes, the full alternating voltage, which is applied to the intermediate electrode is transmitted to the sensor electrode through the conductance of the extension which bridges the intermediate space between the intermediate electrode and the sensor electrode. The portion of the extension which bridges the intermediate space between the intermediate electrode and the earth electrode does not influence that voltage transmission.

Thus, the evaluating circuit measures the full alternating voltage between the sensor electrode and the earth electrode when the probe is not covered by the filling material and measures a substantially lower alternating voltage when the probe is covered. This voltage difference is a clear and certain criterion as to whether the level has reached the probe or not.

Since the two resistance branches of the potentiometer are formed by the filling material or by the filling material extension, variations in the

conductivity of the filling material act in the same manner on the two resistance branches. Thus, the voltage divider ratio of the potentiometer remains substantially constant independent of the variations in conductivity. Thus, the level limit switch can be used for various kinds of filling material or for filling material of changing conductivity without a change in the compensation being necessary.

Formation of an extension on the probe has practically no influence on the operation of the level limit switch. Due to the insensitivity to an extension, probes can be used with substantially smaller dimensions than with the usual conductivity indicators. Furthermore, the probes can have very different forms.

Further features and advantages of the invention will be apparent from the following description of embodiments which are illustrated in the drawing. In the drawing:

Figure 1 shows a diagrammatic representation of a container including an electrically conducting filling material and provided with a level limit switch according to the invention.

Figure 2 is a simplified representation for explaining the operation of the level limit switch when the probe is not immersed in the filling material,

Figure 3 shows the equivalent electrical circuit of the condition illustrated in Figure 2,

Figure 4 is a simplified representation for explaining the operation of the level limit switch when the probe is immersed in the filling material,

Figure 5 is the equivalent electrical circuit of the condition illustrated in Figure 4,

Figure 6 is the front view of another form of probe, and

Figure 7 is a sectional view of the probe in Figure 6.

Very diagrammatically, Figure 1 shows a container 1 the container wall of which consists of metal. The container 1 contains an electrically conducting filling material 3. A rod like probe 4 is fixed at a height h above the base of the container 1. The probe 4 consists of probe rod 5 which is so fixed by a threaded head 6 screwed into an opening in the container wall 2 that it projects horizontally into the interior of the container 1. A sensor electrode 7 is arranged at the free end of the probe rod 5. An intermediate electrode 8 is so arranged between the sensor electrode 7 and the threaded head 6 somewhat in the centre of the probe rod 5 that it is not only arranged at a distance from the sensor electrode 7 but also at a distance from the threaded head 6. The threaded head 6 is in electrically conducting connection with the metallic container wall 2 and together with the said metal wall forms an earth electrode which, as a whole, is referenced to 9. The electrodes 7 and 8 are insulated from one another and from the earth electrode 9. For this purpose, the probe rod 5 can consist of insulating material; if it consists of metal, the electrodes 7 and 8 are insulated from the probe rod 5 in a suitable manner.

In Figure 1, the size of the probe 4 is clearly exaggerated in relationship to the size of the container 1. Furthermore, the electrode connections are shown only very diagrammatically; in reality, they lead to the electrodes through the threaded head 6 and through the probe rod 5.

In association with electronic circuits, the probe 4 serves for ascertaining whether the level in the container 1 has reached the height h or not. For this purpose, an alternating voltage generator 10 is provided which delivers an alternating voltage of suitable frequency and amplitude at its output terminals 10a, 10b. The terminal 10a, which is connected to earth, is connected to the threaded head 6, thus to the earth electrode 9. The intermediate electrode 8 is connected to the terminal 10b. Thus, the output alternating voltage from the generator 10 lies between the intermediate electrode 8 and the earth electrode 9.

The alternating voltage tapped off at the sensor electrode 7 is applied to the input to an evaluating circuit 11. The evaluating circuit 11 includes an amplifier 12 one input terminal of which is connected to the sensor electrode 7 and the other input terminal of which is connected to earth. Thus, the alternating voltage prevailing between the sensor electrode 7 and the earth electrode 9 is applied to the input to the amplifier 12.

A rectifying circuit 13 is connected in the evaluating circuit 11 beyond the amplifier 12 and rectifies the amplified alternating voltage from the amplifier 12. The rectified voltage is fed to the input to a threshold circuit 14 the output voltage from which assumes one or the other of two values according as to whether the rectified voltage supplied to the input lies above or below a set threshold value. The threshold circuit 14 can be formed, for example, by a Schmitt-Trigger. The output signal from the threshold circuit 14 can be supplied in the usual manner to an indicating device 15 which indicates whether or not the level in the container 1 has reached the height h; if desired switching operations can, of course, also be initiated by the same output signal.

The method of operation of the level limit switch illustrated in Figure 1 will now be described with the aid of Figures 2 to 5.

Once again, Figure 2 shows the arrangement of Figure 1 in a simplified representation in the operating condition which applies in the case where the level in the container 1 has not reached the height of the probe 4. Furthermore, in Figure 2 it is assumed that an extension 17 from the filling material has formed on the probe rod 5. The extension 17 has substantially the same specific conductance as the filling material 3 and thus represents an electrical connection between the sensor electrode 7, the intermediate electrode 8 and the earth electrode 9 associated with a certain resistance. The equivalent electrical resistances of the extension 17 are shown dotted in Figure 2; the resistor R1 represents

the resistance of that portion of the extension 17 connecting the intermediate electrode 8 to the earth electrode 9 and the resistor 2 represents the resistance of that portion of the extension 17 which connects the sensor electrode 7 to the intermediate electrode 8. The resistor R2 is in parallel with the resistor 16 the resistance value of which is referenced R16.

Figure 3 shows the equivalent electrical circuit of the arrangement in the condition of Figure 2. The alternating voltage U_G provided by the alternating voltage generator 10 is applied between the intermediate electrode 8 and the earth electrode 9. The intermediate electrode 8 is connected on the one hand to the earth electrode 9 through the resistor R1 and is connected on the other hand to the sensor electrode 7 through the parallel circuit comprising the resistors R2 and R16.

Thus, the voltage U_S tapped off between the sensor electrode 7 and the earth electrode 9 is the same as the alternating voltage U_G delivered by the generator 10. The resistor R1 does of course load the generator 10 but it does not influence the voltage U_S.

Figure 4 shows the operating condition in which the filling material 3 has reached the height of the probe 4. Now, in addition to the extension 17, the filling material provides a conductive connection between the electrodes 7, 8 and 9. The conductive connection between the intermediate electrode 8 and the earth electrode 9 produced by the filling material is illustrated symbolically in Figure 4 by the resistor R3 whereas the resistor R4 represents the conductive connection between the sensor electrode 7 and the intermediate electrode 8 produced by the filling material.

Furthermore, the filling material provides a conductive connection between the sensor electrode 7 and all of the container wall 2 contacted by the filling material. This conductive connection is illustrated symbolically by the resistor R5.

The corresponding equivalent circuit is shown in Figure 5. It differs first of all from the circuit of Figure 3 by the fact that the resistor R3 is in parallel with the resistor R1 and the resistor R4 is in parallel with the resistor R2. However, only the effective values of all the resistors are reduced by this parallel circuit without the operation of the arrangement being basically altered.

On the other hand, the resistor R5 is now in series with the parallel circuit comprising the resistors R2, R4, R16 between the electrodes 8 and 9 so that these resistors form a voltage divider the centre tapping of which is the sensor electrode 7. Thus, the voltage U_s tapped off by the sensor electrode 7 is lower than the generator voltage U_G according to the voltage divider ratio of this voltage divider.

The threshold value of the threshold circuit 14 in the evaluating circuit 11 (Figure 1) is so adjusted that, in the case of Figure 3 the direct voltage produced by rectification of the output voltage of U_S lies above said threshold value and in the case of Figure 5 it lies below the threshold value. Thus, the evaluating circuit 11 can clearly differ between the two operating conditions illustrated in Figure 2 and in Figure 4 and deliver at the output an output signal which has one signal value in the operating condition of Figure 2 and as the other signal value in the operating condition of Figure 4.

It must be noted, that in comparison to the resistors R2 and R4, the resistor R5 has a comparatively lower resistance value since it represents the current cross-section of the entire filling material in the container. Thus, the voltage divider ratio U_S/U_G of the voltage divider formed on the one hand by the resistors R2, R4 and on the other hand by the resistor R5 is substantially less than 1:1 so that the values of the voltage U_S are clearly different from one another in the two operating conditions of Figure 2 and Figure 4. Thus, the evaluating circuit 11 can distinguish these voltage values from one another with a good safety separation.

The purpose of the resistor 16 is simply to guarantee a transmission of the voltage from the intermediate electrode 8 to the sensor electrode 7 in the operating condition of Figure 2 even when no extension has formed on the probe.Thus, the resistance value R16 can be selected high with respect to the values of the resistors R2 and R4 so that the voltage divider ratio is not markedly influenced by the resistor R16.

A variation in the specific conductance of the filling material 3 in the container has practically no influence on the voltage divider ratio since it varies the values of the resistors R2, R4 and R5 in the same ratio. Thus, the function of the level limit switch remains substantially unaltered as a result of a variation in the specific conductance of the filling material without a fresh compensation of the threshold value in the evaluating circuit 11 being necessary. This applies also to the case where the same level limit switch is used for various filling materials of different conductivity.

Furthermore, it must be appreciated that the formation of the extension 17 on the probe 4 has no disadvantageous influence on the operation of the level limit switch either. When the extension 17 is not present it means that the resistors R1 and R2 are absent. The removal of the resistor R1 simply means that the alternating voltage generator 10 is loaded to a lesser extent. In the case of Figures 2 and 3, the resistor R16 undertakes the function of the resistor R2 and in the case of Figure 5 the voltage divider is formed by the resistors R4 and R5.

With regard to the design of the alternating voltage generator 10 it must be noted that this generator is very differently loaded according to the conductance of the filling material 3 and the level in the container. However, the correct operation of the level limit switch presumes that the output voltage U_G remains substantially constant independent of the load. Thus, the generator 10 must be of very low resistance and

be designed so that it can be loaded sufficiently highly. In practise, it has provided to be sufficient if the alternating voltage delivered by the alternating voltage generator 10 has an effective value of about 0.4 volts. With a total value of the resistance of the filling material in the container of substantially 1Ω as arises in practise, the generator must then deliver a current of about 0.4 amps.

The frequency of the altenating voltage delivered by the generator 10 can be selected within a large range. It is quite possible to operate at the mains frequency of 50 Hz; the alternating voltage can then be derived from the mains alternating voltage. However, with filling materials of low resistance, it has proved to be an advantage to operate at higher frequencies; frequencies up to 20 kHz can be used with success.

The shape and position of the electrodes of the probe can be made very different according to the particular application. The level limit switch is in no way limited to the use of rod like probes as in the previously described embodiment. For example, an annular probe is illustrated in Figures 6 and 7 in which the annular intermediate electrode 8′ surrounds the sensor electrode 7′ concentrically at a distance and in its turn the centre electrode surrounds the annular earth electrode 9′ at a distance. As Figure 7 shows, the earth electrode 9′ can be formed by a plate like metal plate 18 which has a shallow recess in which is inserted a disc 19 of insulating material. The electrodes 7′ and 8′ are formed by metal coatings on the disc 19. The connections (not shown) for the electrodes 7′ and 8′ can pass through the metal plate 18 and the disc 9.

With any selected probe construction, it is simply necessary for achieving the desired function for the intermediate electrode to which the alternating voltage is applied to be so arranged between the sensor electrode and the earth electrode that the intermediate spaces can be bridged by a possible formation of an extension.

The use of the above described level limit switch is not even limited to the case in which the container for the filling material consists of metal. For use in insulating containers, care must simply be taken that an earth electrode of sufficient size is applied so that it comes into contact at least with the filling material outside a possible extension formation when the filling material covers the probe. This can be achieved, for example, by a metal plate arranged on the base of the container or by a metal surface of sufficient size surrounding the threaded head of the probe.

Claims

1. A level limit switch for electrically conducting filling materials, comprising a probe arranged at the height of the level to be ascertained and having a sensor electrode arranged to come into electrical contact with the filling material when the latter has reached the level to be ascertained and an intermediate electrode, the switch further comprising an earth electrode arranged to come into electrical contact with the filling material at least when the latter has reached the level to be ascertained, means for applying an alternating voltage between the earth and intermediate electrodes and an evaluating circuit connected to the sensor and earth electrodes to respond to variations in the electrical signal between the sensor electrode and the earth electrode.

2. A level limit switch according to claim 1, in which the sensor electrode and the intermediate electrode are connected to one another by a resistor.

3. A level limit switch according to claim 1 or 2, in which, with a metal container for the filling material, the earth electrode is formed by the container wall.

4. A level limit switch according to any one of claims 1—3, in which the probe is rod like and the sensor electrode and the intermediate electrode are arranged spaced from one another in the longitudinal direction of the probe rod.

5. A level limit switch according to any one of claims 1—3, in which the intermediate electrode is annular and is arranged concentrically with respect to the sensor electrode.

6. A level limit switch substantially as herein described with reference to Figures 1 to 2 or Figures 6 and 7 of the accompanying drawings.

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